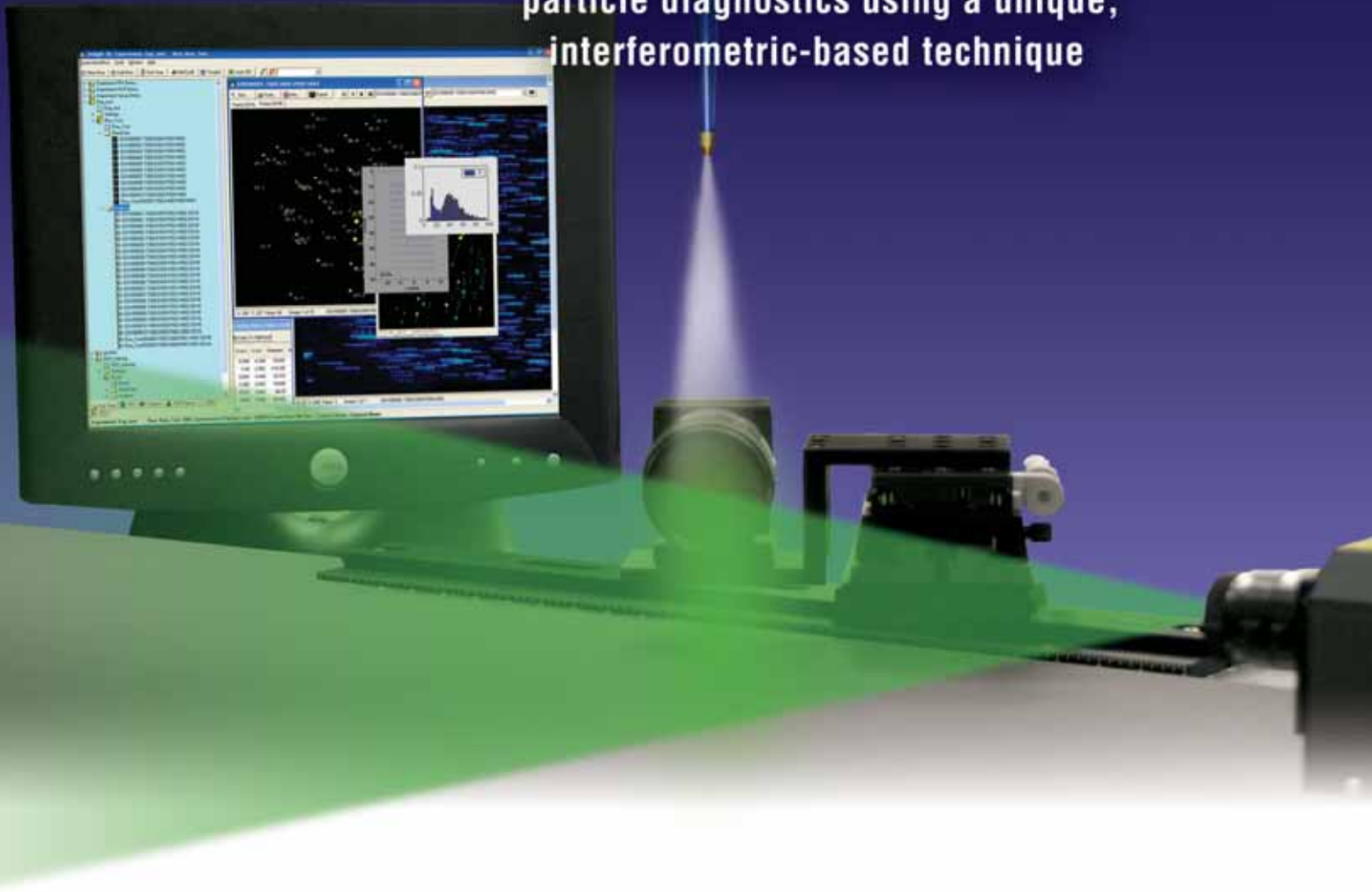# Global Sizing Velocimetry (GSV) System

…For Simultaneous Size and Velocity Measurement

TSI®

TSI GSV Systems…Global size and velocity measurements for comprehensive flow and particle diagnostics using a unique, interferometric-based technique

…the next generation of flow and spray analysis–exclusively from TSI!

- Gives global droplet sizing and velocity measurements instantaneously
- Measures size and velocity using a single camera
- Measures and displays results on-line
- Optimal signal collection angle permits wide range of droplet characteristics
- Measures particles of different refractive indices
- Unique PM windowed algorithm technique provides high sizing accuracy
- Optical arrangement using optimal aperturing increases the maximum allowable concentration limit
- Special particle tracking algorithm ensures accurate velocity measurement
- Simple, easy extension from a single-camera PIV system
- Displays size and velocity vector fields simultaneously
- Gives detailed size and velocity statistics, including size-velocity correlations
- POWERVIEW™ camera family allows wide range of measurement region sizes and image capture rates

Operating Principles

The high accuracy and robustness of Global Sizing Velocimetry (GSV) is based on the Generalized Scattering Imaging (GSI) approach for droplet sizing, which uses both the Lorenz-Mie theory and the Finely Stratified Sphere Scattering model. GSV is not sensitive to droplet refractive index, meaning that measurements can be made on inhomogeneous droplets, reacting or burning droplets, and droplets of unknown refractive index.

Due to the similar nature of Doppler bursts and GSV fringe patterns (one-dimensional), concepts similar to those used in the TSI LDV/PDPA signal processor are adapted for GSV size processing. A high-speed analysis approach identifies the "fringe pattern" generated by the particles. This unique, time-efficient technique–PM windowed algorithm*–ensures that only valid fringe patterns are processed and the particle size information is obtained accurately. Built-in validation schemes use factors such as peak count, intensity variation within the fringe pattern, and fringe pattern SNR to identify a valid particle fringe image.

Similar to PIV, the GSV camera image capture mode also takes two consecutive images from each capture sequence. The two images, taken using a known laser pulse separation time, are used to determine particle displacement in the field. Particle size is measured from the two images using the PM windowed algorithm, as shown in the figure to the right. Since the sequence of the two images is known, particle motion also can be resolved.

Using a unique tracking technique based on the particle size and particle motion information, the 2-D velocity of particles are measured. An image correlation scheme applied to the measured velocity gives sub-pixel displacement accuracy. Since the pulse separation of the two captured images can be varied, measurement of velocities ranging from a few mm/s to a few hundred m/s is possible.

*Patent Pending
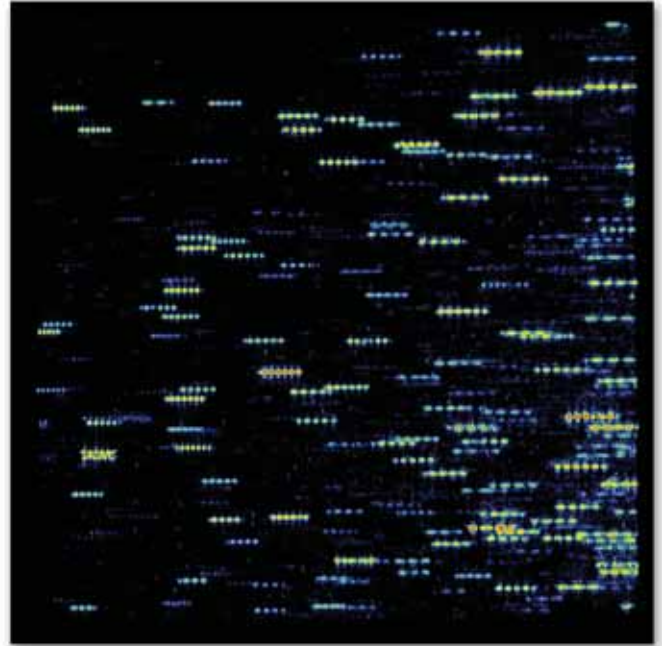
Output of the GSV imaging system provides a unique one-dimensional "fringe" pattern. Each horizontal pattern indicates the presence of a particle.
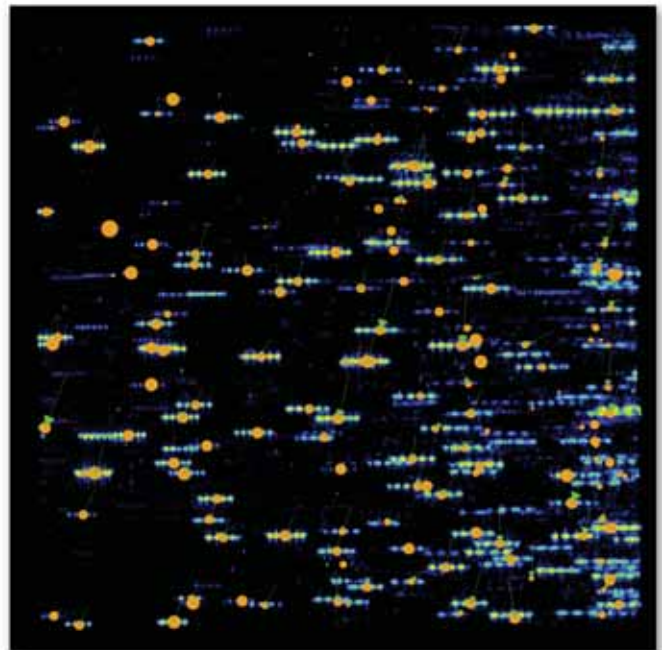

Display of particle sizes and velocities processed using INSIGHT 3G. Figure shows particles measured from two images in a single capture sequence.

TSI's powerful and versatile *INSIGHT* 3G software has been expanded to encompass GSV analysis. The GSV image capture includes interactive timing control and feedback to ensure the appropriate laser pulse separation is selected for accurate velocity measurements. Image conditioning and on-line look-up tables help to optimize the measurement for the best image quality.

System setup parameters, including the defocusing distance, F#, and stand-off distance, must be input before a set of images is saved to ensure the correct analysis is performed. Options for analyzing particle size, particle velocity or both are included. Separate processing dialog boxes for size and velocity allow the user to fine tune the analysis process. Display of particle size and/or velocity is on-line on the fringe images. A user can view particle size with size labels or many other display formats for size and velocity.

Once the analysis is performed, the data file is saved automatically. Various visualization tools for data analysis are supplied in the Tecplot® presentation software integrated with the *INSIGHT* 3G package. Histograms, color-coded scatter plots, contour plots, vector plots and diameter statistics are all easily available to help extract hidden trends and correlations in the data.
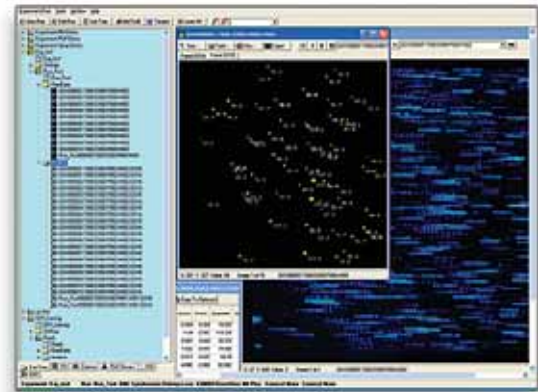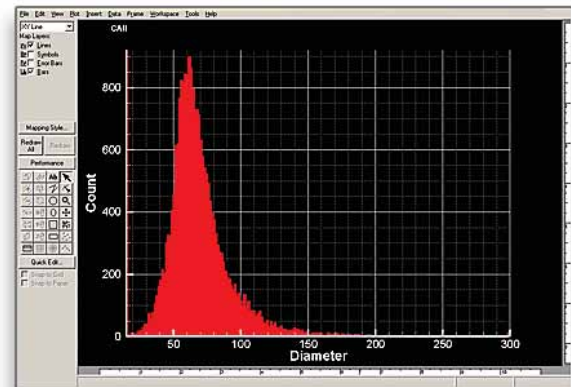

INSIGHT 3G *software display of fringe images, particle size with labels, data set, and size and velocity statistics.*
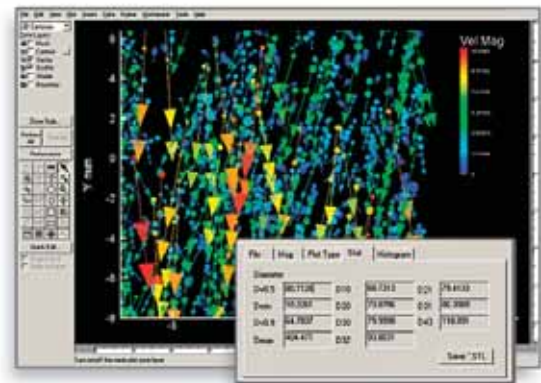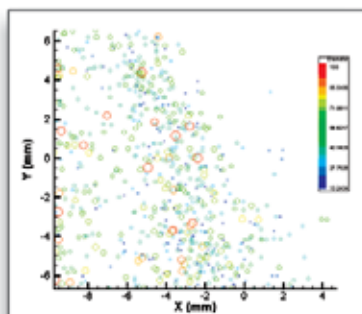

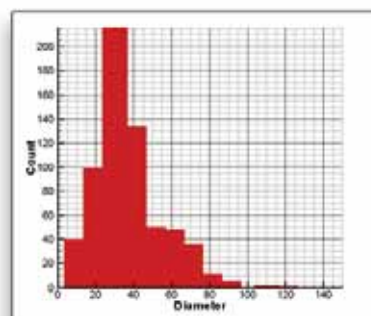*Presentation of Size and Velocity in Tecplot.*
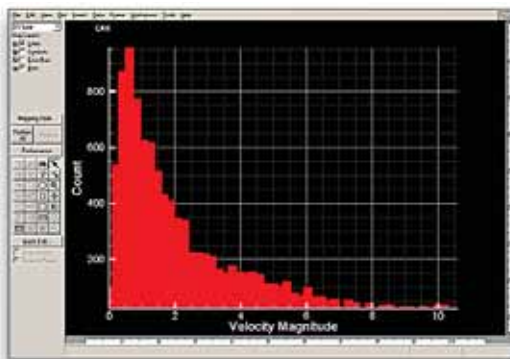
Velocity histogram from GSV analysis.

Diameter histogram from GSV analysis.


Droplet size and location for G-DI spray.

Diameter distribution for G-DI spray.

TSI was among the first to provide global PIV velocity measurement systems. Incorporating Hart Correlation and other patented processing algorithms, TSI PIV systems have provided flow field information with very high spatial resolution and accuracy for several years. Today, they outperform all other PIV systems, thanks to TSI's *INSIGHT 3G* Data Analysis and Display Software and POWERVIEW Plus cameras, the only cameras designed specifically for laser-based global imaging applications. TSI also has a long history of interferometric sizing with its Phase Doppler Particle Analyzer (PDPA) diagnostics systems.

standard 105mm camera lens with a GSV aperture. A specially made camera mount and precision rails allow easy camera setup at the optimum GSV viewing angle, and quick positioning for measurement at multiple locations in the spray.

System setup is made as simple as possible. A unique, high-speed compensation process accounts for the effect of the optimum viewing angle, minimizing setup and alignment issues. The only setup step involves use of a calibration target or other approaches to determine the magnification.
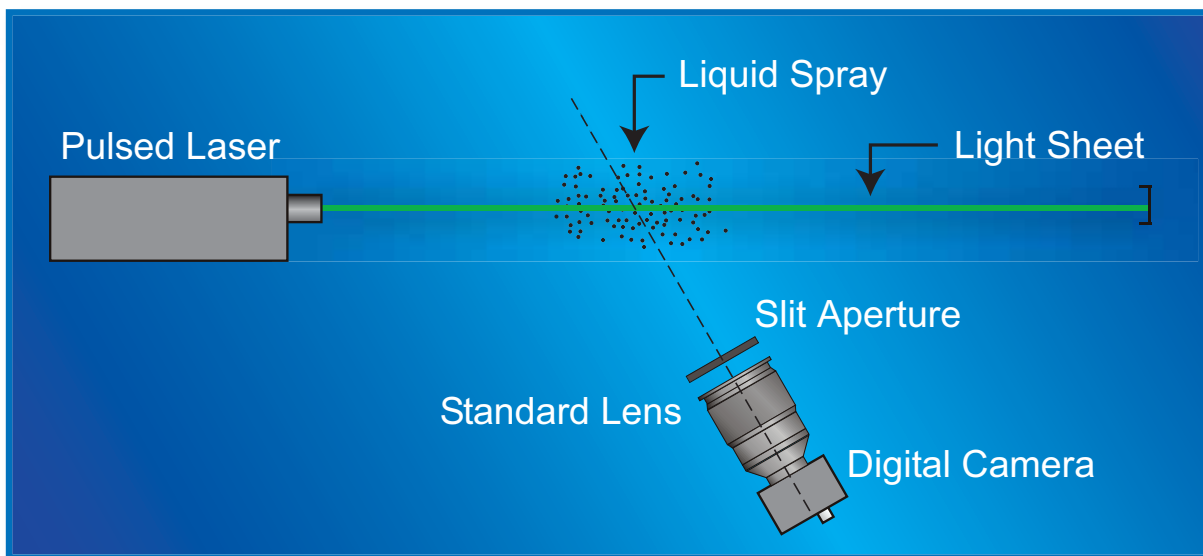
System schematic diagram showing the laser and camera configuration.

Now, we've combined our expertise in global imaging and interferometry to bring you the all-new Global Size and Velocity (GSV) System! The TSI GSV system measures particle and droplet size and velocity in sprays and other multiphase flows. Size is measured using an interferometric technique, ensuring highly accurate results. Velocity is extracted from the same interferometric images using a unique, powerful tracking algorithm. The GSV system employs a double-pulsed Nd:YAG laser typically used for PIV along with suitable light sheet optics that form the light sheet. The TSI POWERVIEW Plus camera incorporates a

Automated processing is possible for most flows. The TSI GSV system is designed to outperform other interferometric imaging systems, especially for high-concentration measurements. Using a POWERVIEW Plus 4MP camera fitted with the unique viewing aperture, a GSV system is ideal for diagnosing a wide range of flows. The system also works with all other models in the TSI POWERVIEW series of cameras. Thus, a wide range of measurement region sizes and image capture rates are possible. The GSV system provides a high data rate while maintaining a high degree of accuracy and reliability.

Specifications

Global Sizing Velocimetry System

Particle Type	Droplets, transparent with various refractive indices
Particle Shape	Spherical
Particle Size Range	8 to 600μm (typical)
Field of View	100 to 400 mm^2, typically 15 x 15mm; three times FOV with 11MP camera
Working Distance	200 to 500 mm; longer working distance with zoom lens
Particle Concentration	Up to ~3000 #/cc

Other Systems from TSI

TSI provides a wide range of global diagnostics systems to measure velocity and property fields. They include PLIF systems, simultaneous PLIF/PIV measuring systems, 2D PIV systems, StereoPIV systems, MicroPIV systems, time-resolved PIV systems, high-speed time-resolved MicroPIV systems, and custom PIV systems for special applications. The advanced *INSIGHT 3G* diagnostics software package is used with all the image diagnostics systems, allowing a smooth and easy transition from one measuring system to another.

TSI Phase Doppler Particle Analyzer/Laser Doppler Velocimeter (PDPA/LDV) systems incorporate an array of technical innovations that revolutionized particle size and velocity measurements. We originated the single-receiver, three-detector scheme; launched optical fiber technology for transmitter and receiver systems; and offered the first digital signal processors for particle size and velocity measurements. Continuous innovations make them the most versatile, accurate PDPA/LDV systems available.

Specifications subject to change without notice.
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